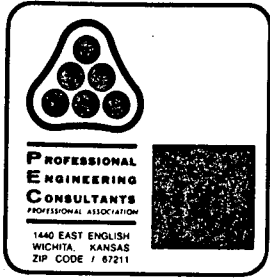


MEMO



TO: Mr. Mike Lindebak, P.E. PROJECT NO. 36-82493-552
PROJECT: Northborough 3rd Add'n.
ATTN: Ms. Vicki Huang DATE: July 21, 1986

COPIES TO:

File
Forrest Nagley, MAPD

FROM: Charles S. Brown, P.E.
REFERENCE: Revised Drainage Plan

PLEASE ADVISE IMMEDIATELY OF ANY MISCONCEPTIONS OR OMISSIONS YOU BELIEVE TO BE CONTAINED HEREIN.

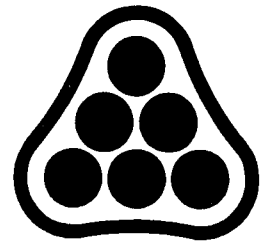
As requested, we are transmitting herewith two (2) copies of the "Revised Drainage Plan & Supporting Calculations" for Northborough 3rd Addition.

We have analyzed the 5-year storm in lieu of the 2-year storm which was utilized for Northborough 2nd Addition.

Pipe sizes from Rockhill Street to the detention pond were increased from 42" to 48". All other pipe sizes remained the same. You will also note in the calculations that some 15' inlets will be required in lieu of the 10' inlets noted in the previous submittal.

If you have any questions, please advise.

CSB/mkm



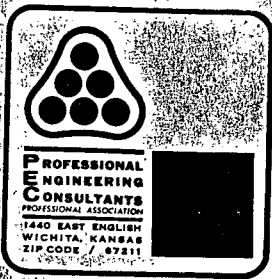
PROFESSIONAL
ENGINEERING
CONSULTANTS
PROFESSIONAL ASSOCIATION

REVISED DRAINAGE PLAN
AND
SUPPORTING CALCULATIONS

FOR
NORTHBOROUGH 3RD ADDITION
TO WICHITA, SEDGWICK COUNTY, KANSAS

PREPARED BY
PROFESSIONAL ENGINEERING CONSULTANTS, P.A.
ENGINEERS
WICHITA, KANSAS

JULY 21, 1986



Date June 18, 1986 Page 1 of 16

Project Northborough 3rd Addition

Item Drainage Plan

STORM SEWER SYSTEM 100

Determine Areas:

Node

Plan. Units

Area SF

Area Acres

104

723

115,680

2.7

103

2233

357,200

8.2

102

2937

149,920

3.4

101

Manhole

.1

100

Outlet

206

1717

114,720

2.6

205

2230

356,800

8.2

204

Manhole

.1

203

1550

248,000

5.7

202

979

156,640

3.6

201

Manhole

.1

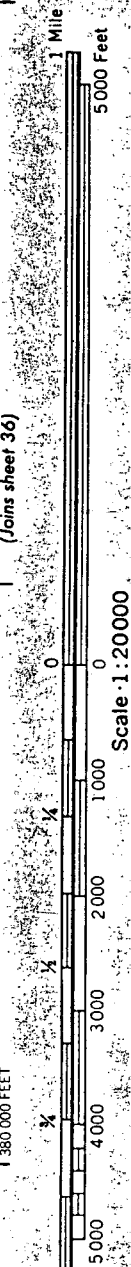
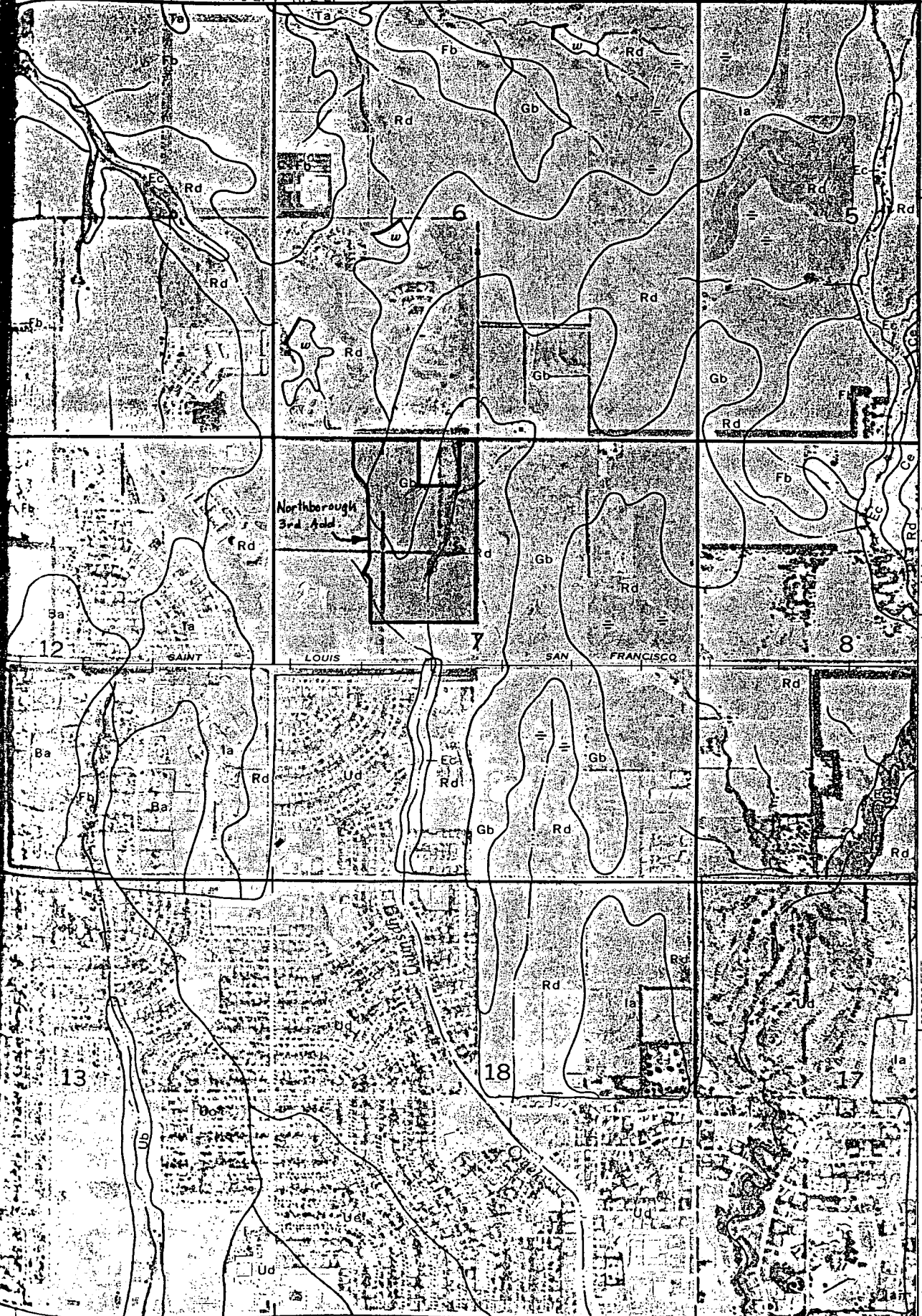
200

Outlet

Use Rational Method For All Sub-Basins

From page 2, soil type = D

R. 1 E. R. 2 E (Joins sheet 27)



(Joins sheet 43) 2,305,000 FEET |

Soil Types Gb D Northborough 3rd Ad.
Rd D Drainage Plan



Date June 18, 1986 Page 3 of 16

Project Northborough 3rd Addition

Item Drainage Plan.

Determine Runoff Coefficients For Each Sub-Basin
(5-year)

<u>Node</u>	<u>Land Use</u>	<u>%</u>	<u>C</u>	<u>Composite C</u>
104	Offices / Clinics	77	0.69	0.73
	Street R-O-W	23	0.88	
103	Offices / Clinics	85	0.69	0.72
	Street R-O-W	15	0.88	
102	Unknown offsite	88	0.54	0.58
	Street R-O-W	12	0.88	
101, 100	Manhole + outlet			
203	Offices / Clinics	86	0.69	0.72
	Street R-O-W	14	0.88	
205	Financial Institutions	28	0.69	0.71
	Offices / Clinics	61	0.69	
	Street R-O-W	11	0.88	
206	Multi-Family (Apt)	65	0.73	0.78
	Street R-O-W	35	0.88	
204	- (Man hole) -			-
202	Multi-Family (Apt)	76	0.73	0.77
	Street R-O-W	24	0.88	
201, 200	Man hole + outlet			-



Date June 18, 1986 Page 4 of 16

Project Northborough 3rd Addition

Item Drainage Plan.

Determine Runoff Coefficients For Each Sub-Basin
(100-year)

Node	Land Use	%	c	Composite c
104	Offices / Clinics	77	0.80	0.83
	Street R-O-W	23	0.93	
103	Offices / Clinics	85	0.80	0.82
	Street R-O-W	15	0.93	
102	Unknown off site	88	0.68	0.71
	Street R-O-W	12	0.93	
101, 100	Manhole & Outlet			
203	Offices / Clinics	86	0.80	0.82
	Street R-O-W	14	0.93	
205	Financial Institutions	28	0.80	0.81
	Offices / Clinics	61	0.80	
	Street R-O-W	11	0.93	
206	Multi Family (Apt)	65	0.86	0.88
	Street R-O-W	35	0.93	
204	- (Man hole) -			
202	Multi-Family (Apt)	76	0.86	0.88
	Street R-O-W	24	0.93	
201, 200	Manhole & Outlet			



Date June 18, 1986 Page 5 of 16

Project Northborough 3rd Addition

Item Drainage Plan

Assume $t_c = 15$ minutes for each sub-basin.

$\therefore I_5 = 4.56$ $I_{100} = 7.37$

Node	C_s	I_5	A	Q_s
104	0.73	4.56	2.7	9.0
103	0.72	4.56	8.2	26.9
1102	0.58	4.56	3.4	9.0
101, 100	Manhole & outlet			
203	0.72	4.56	5.7	18.7
205	0.71	4.56	8.2	26.5
206	0.78	4.56	2.6	9.2
204	Manhole			
202	0.77	4.56	3.6	12.6
201, 200	Manhole & outlet			



Date June 18, 1986 Page 6 of 16

Project Northborough 3rd Addition

Item Drainage Plan

Node	C_{100}	I_{100}	A	F	Q_{100}
104	0.83	7.37	2.7		16.5
103	0.82	7.37	8.2		49.6
102	0.71	7.37	3.4		17.8
101, 100	Manhole	+ Outlet			
203	0.82	7.37	5.7		34.4
205	0.81	7.37	8.2		49.0
206	0.88	7.37	2.6		16.9
204	Manhole				
202	0.88	7.37	3.6		23.3
201, 200	Manhole	+ Outlet			



Date June 18, 1986 Page 7 of 16

Project Northborough 3rd Addition

Item Drainage Plan.

Defermine

Node	Q _s	Inlet Condition	Q # approach	L	LT*	E ^{††}	Q _{int.} **	Q _{bypass}	to
104	9.0	On grade	9.0	10'	36'	43%	3.9	5.1	Node 203
103	26.9	Sump	26.9	15'		100%	26.9	0.0	-
102	9.0	On grade	9.0	10'	30'	40%	3.6	5.4	Node 202
101, 100 203	Manhole + 18.7	Outlet Sump	18.7+5.1 = 23.8	15'		100%	23.8	0.0	-
205	26.5	Sump	26.5	15'		100%	26.5	0.0	-
206	9.2	Sump	9.2	5'		100%	9.2	0.0	-
204	-	Manhole	-	-		-	-	-	-
202	12.6	Sump	12.6+5.4 = 18.0	10'		100%	18.0	0.0	-
201, 200	Manhole +	Outlet							

approach Q = Q_s + Q_{bypassed from other nodes}

* see page 16

†† see page 15

** this Q used in storm sewer program

ATTACHMENT A
DRAINAGE CRITERIA MANUAL

CITY OF WICHITA, KANSAS

RAINFALL INTENSITY TABLE FOR SEDGWICK COUNTY, KANSAS

The following tabulation contains rainfall intensity in inches per hour as derived from ESSA Weather Bureau Technical Paper 40 Modified to NWS Hydro-35, 1977 During First Hour

DURATION IN MINUTES	RETURN PERIODS OF						
	1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
5	4.18	5.57	6.53	7.41	8.52	9.48	10.32
6	3.99	5.32	6.25	7.09	8.16	9.09	9.89
7	3.81	5.09	5.99	6.81	7.84	8.74	9.50
8	3.66	4.89	5.75	6.55	7.55	8.42	9.15
9	3.52	4.70	5.54	6.31	7.28	8.13	8.83
10	3.39	4.52	5.34	6.09	7.04	7.86	8.54
11	3.27	4.36	5.16	5.89	6.81	7.61	8.27
12	3.18	4.21	4.99	5.71	6.60	7.38	8.02
13	3.05	4.08	4.84	5.53	6.41	7.17	7.79
14	2.96	3.95	4.69	5.37	6.23	6.97	7.57
15	2.87	3.83	4.56	5.22	6.06	6.78	7.37
16	2.78	3.72	4.43	5.08	5.90	6.60	7.18
17	2.71	3.61	4.31	4.95	5.75	6.44	7.00
18	2.63	3.51	4.20	4.83	5.61	6.29	6.84
19	2.56	3.42	4.10	4.71	5.47	6.14	6.68
20	2.50	3.33	4.00	4.60	5.35	6.00	6.53
21	2.44	3.25	3.90	4.50	5.23	5.87	6.39
22	2.38	3.17	3.81	4.40	5.12	5.75	6.26
23	2.32	3.10	3.73	4.31	5.01	5.63	6.13
24	2.27	3.03	3.65	4.22	4.91	5.52	6.01
25	2.22	2.96	3.57	4.13	4.81	5.41	5.90
26	2.20	2.90	3.50	4.05	4.72	5.31	5.79
27	2.16	2.84	3.43	3.98	4.63	5.21	5.69
28	2.14	2.78	3.37	3.90	4.55	5.12	5.59
29	2.11	2.72	3.30	3.83	4.47	5.03	5.49
30	2.08	2.67	3.24	3.76	4.39	4.94	5.40
31	2.05	2.62	3.19	3.70	4.32	4.86	5.32
32	2.02	2.57	3.10	3.63	4.25	4.79	5.22
33	1.99	2.52	3.05	3.57	4.18	4.71	5.14
34	1.96	2.48	3.01	3.51	4.11	4.63	5.07
35	1.93	2.44	2.98	3.46	4.05	4.56	5.00
36	1.91	2.39	2.93	3.41	3.99	4.50	4.93
37	1.89	2.35	2.88	3.36	3.93	4.43	4.86
38	1.87	2.32	2.84	3.31	3.87	4.37	4.79
39	1.85	2.28	2.80	3.26	3.82	4.31	4.73
40	1.83	2.24	2.76	3.22	3.76	4.25	4.66
41	1.81	2.21	2.72	3.17	3.71	4.19	4.60
42	1.79	2.18	2.68	3.13	3.66	4.13	4.54
43	1.77	2.14	2.64	3.09	3.61	4.08	4.49
44	1.75	2.11	2.61	3.05	3.57	4.03	4.43
45	1.73	2.08	2.57	3.01	3.52	3.98	4.38

ATTACHMENT A CONTINUED
Page 2

<u>DURATION IN MINUTES</u>	<u>RETURN PERIODS OF</u>						
	<u>1-YR</u>	<u>2-YR</u>	<u>5-YR</u>	<u>10-YR</u>	<u>25-YR</u>	<u>50-YR</u>	<u>100-YR</u>
46	1.70	2.05	2.54	2.97	3.48	3.93	4.33
47	1.67	2.02	2.50	2.93	3.44	3.88	4.28
48	1.66	2.00	2.47	2.90	3.39	3.84	4.23
49	1.64	1.97	2.44	2.86	3.35	3.79	4.18
50	1.61	1.95	2.41	2.83	3.32	3.75	4.13
51	1.59	1.92	2.38	2.79	3.28	3.71	4.09
52	1.56	1.89	2.35	2.76	3.24	3.67	4.05
53	1.54	1.86	2.33	2.73	3.20	3.63	4.00
54	1.52	1.84	2.30	2.70	3.17	3.59	3.96
55	1.50	1.81	2.27	2.67	3.14	3.55	3.92
56	1.47	1.79	2.25	2.64	3.10	3.51	3.88
57	1.45	1.76	2.22	2.61	3.07	3.48	3.84
58	1.43	1.74	2.20	2.59	3.04	3.44	3.81
59	1.42	1.72	2.18	2.56	3.01	3.41	3.77
60	1.40	1.69	2.15	2.53	2.98	3.37	3.73
61	1.38	1.67	2.13	2.51	2.95	3.34	3.70
62	1.36	1.65	2.11	2.48	2.92	3.31	3.67
63	1.34	1.63	2.09	2.46	2.89	3.28	3.63
64	1.33	1.61	2.07	2.44	2.86	3.25	3.60
65	1.31	1.59	2.05	2.41	2.84	3.22	3.57
66	1.30	1.57	2.03	2.39	2.81	3.19	3.54
67	1.28	1.56	2.01	2.37	2.79	3.16	3.51
68	1.26	1.54	1.99	2.35	2.76	3.13	3.48
69	1.25	1.52	1.97	2.33	2.74	3.10	3.45
70	1.24	1.50	1.95	2.31	2.71	3.08	3.42
71	1.22	1.49	1.93	2.28	2.69	3.05	3.39
72	1.21	1.47	1.92	2.26	2.67	3.02	3.36
73	1.20	1.46	1.90	2.25	2.64	3.00	3.34
74	1.18	1.44	1.88	2.23	2.63	2.98	3.31
75	1.17	1.43	1.86	2.21	2.61	2.95	3.29
76	1.16	1.41	1.85	2.19	2.58	2.93	3.26
77	1.15	1.40	1.83	2.17	2.55	2.90	3.24
78	1.13	1.38	1.82	2.15	2.53	2.88	3.22
79	1.12	1.37	1.80	2.14	2.50	2.86	3.19
80	1.11	1.36	1.79	2.12	2.48	2.84	3.16
81	1.10	1.34	1.77	2.10	2.46	2.82	3.13
82	1.09	1.33	1.76	2.08	2.43	2.79	3.10
83	1.08	1.32	1.74	2.06	2.41	2.76	3.07
84	1.07	1.31	1.73	2.04	2.39	2.74	3.04
85	1.06	1.30	1.72	2.02	2.37	2.71	3.01
86	1.05	1.28	1.70	2.00	2.34	2.69	2.99
87	1.04	1.27	1.69	1.99	2.32	2.66	2.96
88	1.03	1.26	1.68	1.97	2.30	2.64	2.93
89	1.02	1.25	1.68	1.95	2.28	2.62	2.91
90	1.01	1.24	1.66	1.93	2.26	2.59	2.88

ATTACHMENT A CONTINUED
Page 3

<u>DURATION IN MINUTES</u>	<u>RETURN PERIODS OF</u>						
	<u>1-YR</u>	<u>2-YR</u>	<u>5-YR</u>	<u>10-YR</u>	<u>25-YR</u>	<u>50-YR</u>	<u>100-YR</u>
91	1.00	1.23	1.65	1.92	2.24	2.57	2.86
92	1.00	1.22	1.63	1.90	2.22	2.55	2.83
93	0.99	1.21	1.62	1.89	2.20	2.53	2.81
94	0.98	1.20	1.61	1.87	2.19	2.51	2.79
95	0.97	1.19	1.59	1.85	2.17	2.49	2.76
96	0.96	1.18	1.58	1.84	2.15	2.46	2.74
97	0.96	1.17	1.57	1.82	2.13	2.44	2.72
98	0.95	1.16	1.56	1.81	2.12	2.42	2.70
99	0.94	1.15	1.54	1.80	2.10	2.41	2.67
100	0.93	1.14	1.53	1.78	2.08	2.39	2.65
101	0.93	1.13	1.52	1.77	2.07	2.39	2.65
102	0.92	1.13	1.51	1.75	2.05	2.35	2.61
103	0.91	1.12	1.50	1.74	2.04	2.33	2.59
104	0.90	1.11	1.49	1.73	2.02	2.31	2.57
105	0.90	1.10	1.47	1.72	2.01	2.30	2.55
106	0.89	1.09	1.46	1.70	1.99	2.28	2.54
107	0.88	1.09	1.45	1.69	1.98	2.26	2.52
108	0.88	1.08	1.44	1.68	1.96	2.25	2.50
109	0.87	1.07	1.43	1.67	1.95	2.23	2.48
110	0.87	1.06	1.42	1.65	1.93	2.21	2.46
111	0.86	1.06	1.41	1.64	1.92	2.20	2.45
112	0.85	1.05	1.40	1.63	1.91	2.18	2.43
113	0.85	1.04	1.39	1.62	1.89	2.17	2.41
114	0.84	1.03	1.38	1.61	1.88	2.15	2.40
115	0.84	1.03	1.37	1.60	1.87	2.14	2.38
116	0.83	1.02	1.36	1.59	1.86	2.12	2.36
117	0.82	1.01	1.36	1.58	1.84	2.11	2.35
118	0.82	1.01	1.35	1.57	1.83	2.09	2.33
119	0.81	1.00	1.34	1.56	1.82	2.08	2.32
120	0.81	0.99	1.33	1.55	1.81	2.07	2.30

<u>DURATION IN HOURS</u>	<u>RETURN PERIODS OF</u>						
	<u>1-YR</u>	<u>2-YR</u>	<u>5-YR</u>	<u>10-YR</u>	<u>25-YR</u>	<u>50-YR</u>	<u>100-YR</u>
2	0.81	0.99	1.33	1.55	1.81	2.07	2.30
3	0.59	0.72	0.97	1.13	1.32	1.51	1.68
4	0.47	0.58	0.78	0.91	1.06	1.21	1.35
5	0.40	0.49	0.66	0.77	0.89	1.02	1.14
6	0.35	0.42	0.57	0.67	0.78	0.89	0.99
8	0.28	0.34	0.46	0.53	0.62	0.71	0.79
10	0.23	0.29	0.39	0.45	0.52	0.60	0.67
12	0.20	0.25	0.33	0.39	0.45	0.52	0.58
18	0.15	0.18	0.24	0.28	0.33	0.38	0.42
24	0.12	0.15	0.20	0.23	0.27	0.31	0.34

ATTACHMENT D

DRAINAGE CRITERIA

CITY OF WICHITA, KANSAS

RECOMMENDED RUNOFF COEFFICIENTS FOR RATIONAL METHOD
AND PERCENT IMPERVIOUS FOR UNIT HYDROGRAPH METHOD

Land Use or Surface Characteristics	Percent Impervious	Frequency			
		2	5	10	100
1. Business:					
Downtown Areas	95	0.84	0.85	0.87	0.91
Neighborhood Areas	70	0.68	0.69	0.73	0.80
2. Residential:					
<u>Single Family (Soil Group D)</u>					
1/8 Acre	50	0.57	0.61	0.66	0.79
1/4 Acre	38	0.50	0.54	0.62	0.76
1/3 Acre	30	0.46	0.50	0.59	0.73
1/2 Acre	25	0.42	0.48	0.56	0.72
3/4 Acre	22	0.42	0.46	0.55	0.71
1 Acre	20	0.41	0.45	0.54	0.71
<u>Multi-Family (Soil Group D)</u>					
Multi-Unit (detached)	60	0.62	0.66	0.72	0.82
Multi-Unit (attached)	65	0.64	0.68	0.73	0.83
Apartments	75	0.70	0.73	0.79	0.86
<u>Single Family (Soil Group C)</u>					
1/8 Acre	50	0.55	0.58	0.64	0.73
1/4 Acre	38	0.48	0.51	0.57	0.68
1/3 Acre	30	0.43	0.46	0.53	0.65
1/2 Acre	25	0.40	0.43	0.50	0.63
3/4 Acre	22	0.39	0.42	0.49	0.62
1 Acre	20	0.37	0.40	0.48	0.61
<u>Multi-Family (Soil Group C)</u>					
Multi-Unit (detached)	60	0.60	0.63	0.69	0.77
Multi-Unit (attached)	65	0.63	0.66	0.71	0.79
Apartments	75	0.68	0.72	0.77	0.83
<u>Single-Family (Soil Group B)</u>					
1/8 Acre	50	0.52	0.54	0.59	0.67
1/4 Acre	38	0.44	0.46	0.52	0.61
1/3 Acre	30	0.39	0.41	0.47	0.57
1/2 Acre	25	0.36	0.38	0.44	0.54
3/4 Acre	22	0.34	0.36	0.42	0.52
1 Acre	20	0.33	0.35	0.40	0.51
<u>Multi-Family (Soil Group B)</u>					
Multi-Unit (detached)	60	0.58	0.60	0.65	0.72
Multi-Unit (attached)	65	0.61	0.64	0.68	0.75
Apartments	75	0.67	0.70	0.74	0.80

Land Use or Surface Characteristics	Percent Impervious	Frequency			
		<u>2</u>	<u>5</u>	<u>10</u>	<u>100</u>
<u>Single Family (Soil Group A)</u>					
1/8 Acre	50	0.47	0.50	0.54	0.60
1/4 Acre	38	0.39	0.41	0.45	0.52
1/3 Acre	30	0.33	0.35	0.39	0.47
1/2 Acre	25	0.30	0.31	0.35	0.44
3/4 Acre	22	0.28	0.29	0.33	0.42
1 Acre	20	0.26	0.28	0.32	0.40
<u>Multi-Family (Soil Group A)</u>					
Multi-Unit (detached)	60	0.55	0.57	0.61	0.67
Multi-Unit (attached)	65	0.58	0.60	0.64	0.70
Apartments	75	0.65	0.68	0.72	0.77
3. Industrial:					
Light Areas	70	0.68	0.69	0.73	0.80
Heavy Areas	80	0.74	0.76	0.79	0.84
4. Playgrounds:					
	15	0.33	0.35	0.42	0.55
5. Schools:					
	40	0.49	0.51	0.56	0.66
6. Railroad Yard Areas:					
	30	0.43	0.45	0.50	0.62
7. Undeveloped Urban Areas: Offsite Flow Analysis (when land use not defined)					
	45	0.52	0.54	0.59	0.68
8. Streets:					
Paved	99	0.87	0.88	0.90	0.93
Gravel	00	0.24	0.26	0.33	0.48
9. Drive, Parking Lots and Walks:					
	96	0.87	0.87	0.88	0.89
10. Roofs:					
	90	0.80	0.85	0.90	0.93
11. Urban Lawn Areas (See Note No. 1 below):					
<u>Soil Group A</u>					
Slope less than 1%	00	0.08	0.09	0.13	0.23
Slope 1% to 4%	00	0.12	0.13	0.17	0.27
Slope more than 4%	00	0.16	0.17	0.21	0.31
<u>Soil Group B</u>					
Slope less than 1%	00	0.16	0.18	0.24	0.37
Slope 1% to 4%	00	0.20	0.22	0.28	0.41
Slope more than 4%	00	0.24	0.26	0.32	0.45
<u>Soil Group C</u>					
Slope less than 1%	00	0.24	0.27	0.35	0.51
Slope 1% to 4%	00	0.26	0.29	0.37	0.53
Slope more than 4%	00	0.28	0.31	0.39	0.55

Land Use or Surface Characteristics	Percent Impervious	Frequency			
		<u>2</u>	<u>5</u>	<u>10</u>	<u>100</u>
<u>Soil Group D</u>					
Slope less than 1%	00	0.28	0.33	0.43	0.63
Slope 1% to 4%	00	0.30	0.35	0.45	0.65
Slope more than 4%	00	0.32	0.37	0.47	0.67

Note No. 1: Coefficients shown in the above table are for pervious open space areas with thick turf which includes pervious areas in parks and cemeteries. Coefficients shown above must be increased 0.02 for use with agricultural pasture areas. Coefficients shown above must be reduced by 0.04 for use with agricultural cultivated areas. Group A soils are well-drained, coarse textured sands with high infiltration rates. Group B soils are moderately well-drained, moderately coarse textured soils with moderate infiltration rates. Group C soils are moderately poor-drained, moderately fine textured soils with slow infiltration rates. Group D soils are poor-drained, fine textured soils with very slow infiltration rates.

GENERAL NOTE: These Rational Formula Coefficients may not be valid for basins 320 acres or larger.

EXHIBIT NO. 1

SOIL LEGEND

<u>SYMBOL</u>	<u>HYDROLOGIC GROUP</u>	<u>NAME</u>
Aa	B	Albion-Shellabarger sandy loams, 1 to 4 percent slopes
Ab	B	Albion and Shellabarger sandy loams, 7 to 15 percent slopes
Ba	C	Blanket silt loam, 0 to 1 percent slopes
Bb	C	Blanket silt loam, 1 to 3 percent slopes
Ca	B	Canadian fine sandy loam
Cb	B	Canadian-Waldeck fine sandy loams
Cc	D	Carwile fine sandy loam
Cd	B	Clark-Ost clay loams, 1 to 4 percent slopes
Ce	C	Cline silty clay, 3 to 6 percent slopes
Ea	B	Elandco silt loam
Eb	B	Elandco silt loam, occasionally flooded
Ec	B	Elandco silt loam, frequently flooded
Fa	B	Farnum loam, 0 to 1 percent slopes
Fb	B	Farnum loam, 1 to 3 percent slopes
Fc	B	Farnum loam, sandy substratum, 0 to 1 percent slopes
Ga	D	Goessel silty clay, 0 to 1 percent slopes
Gb	D	Goessel silty clay, 1 to 2 percent slopes
Ia	D	Irwin silty clay loam, 1 to 3 percent slopes
Ib	D	Irwin silty clay loam, 3 to 6 percent slopes
Ic	D	Irwin silty clay loam, 2 to 6 percent slopes, eroded
La	C	Lesho loam
Lb	A	Lincoln soils
Ma	B	Milan loam, 1 to 3 percent slopes
Mb	B	Milan form, 3 to 6 percent slopes
Mc	B	Milan clay loam, 2 to 6 percent slopes, eroded
Na	B	Naron fine sandy loam
Oc	D	Owens clay loam, 1 to 3 percent slopes
Od	D	Owens-Rock outcrop complex, 3 to 10 percent slopes
Pa		Pits
Pb	D	Plevna fine sandy loam
Pc	A	Pratt loamy fine sand, undulating
Pd	A	Pratt-Tivoli complex, rolling
Ra	D	Renfrow silty clay loam, 1 to 3 percent slopes
Rb	D	Renfrow silty clay loam, 3 to 6 percent slopes
Rc	D	Renfrow-Owens clay loams, 1 to 4 percent slopes
Rd	D	Rosehill silty clay, 1 to 3 percent slopes
Sa	B	Shellabarger sandy loam, 1 to 3 percent slopes
Sb	B	Shellabarger sandy loam, 3 to 6 percent slopes
Sc	B	Shellabarger sandy loam, 3 to 6 percent slopes, eroded
Ta	D	Tabler silty clay loam
Tb	D	Tabler-Drummond complex
Ua	B	Urban land-Canadian complex
Ub	B	Urban land-Elandco complex
Uc	B	Urban land-Farnum complex, 0 to 3 percent slopes
Ud	D	Urban land-Irwin complex, 1 to 3 percent slopes
Ue	D	Urban land-Tabler complex
Va	B	Vanoss silt loam, 0 to 1 percent slopes
Vb	B	Vanoss silt loam, 1 to 3 percent slopes
Vc	B	Vanoss silt loam, 3 to 6 percent slopes
Vd	B	Vanoss silt loam, 3 to 6 percent slopes, eroded
Ve	D	Vernon sandy loam, 1 to 3 percent slopes
Vf	D	Vernon sandy loam, 3 to 6 percent slopes
Wa	C	Waldeck sandy loam
Wb	D	Waurika silt loam

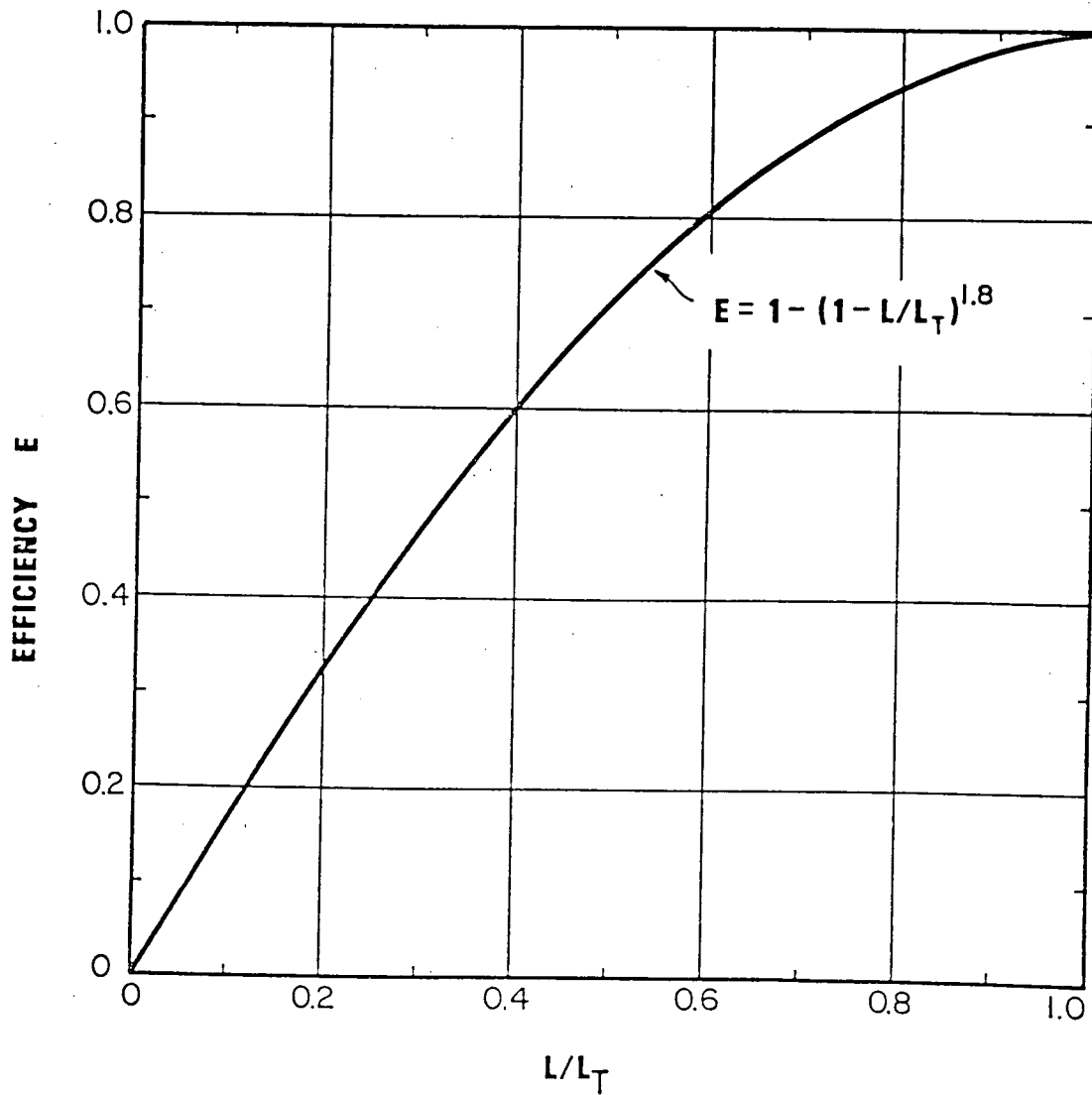


CHART 10. Curb-opening and slotted drain inlet interception efficiency.

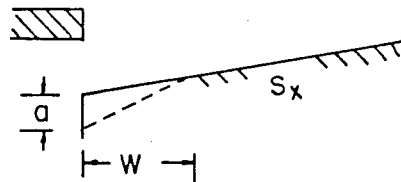
FROM HFD-12, DRAINAGE OF HIGHWAY PAVEMENTS, FHWA, Mar. 1954

Northborough 3rd Addition
Drainage Plan.

16/16

$S_x = 3/8" / FT = 0.03125$

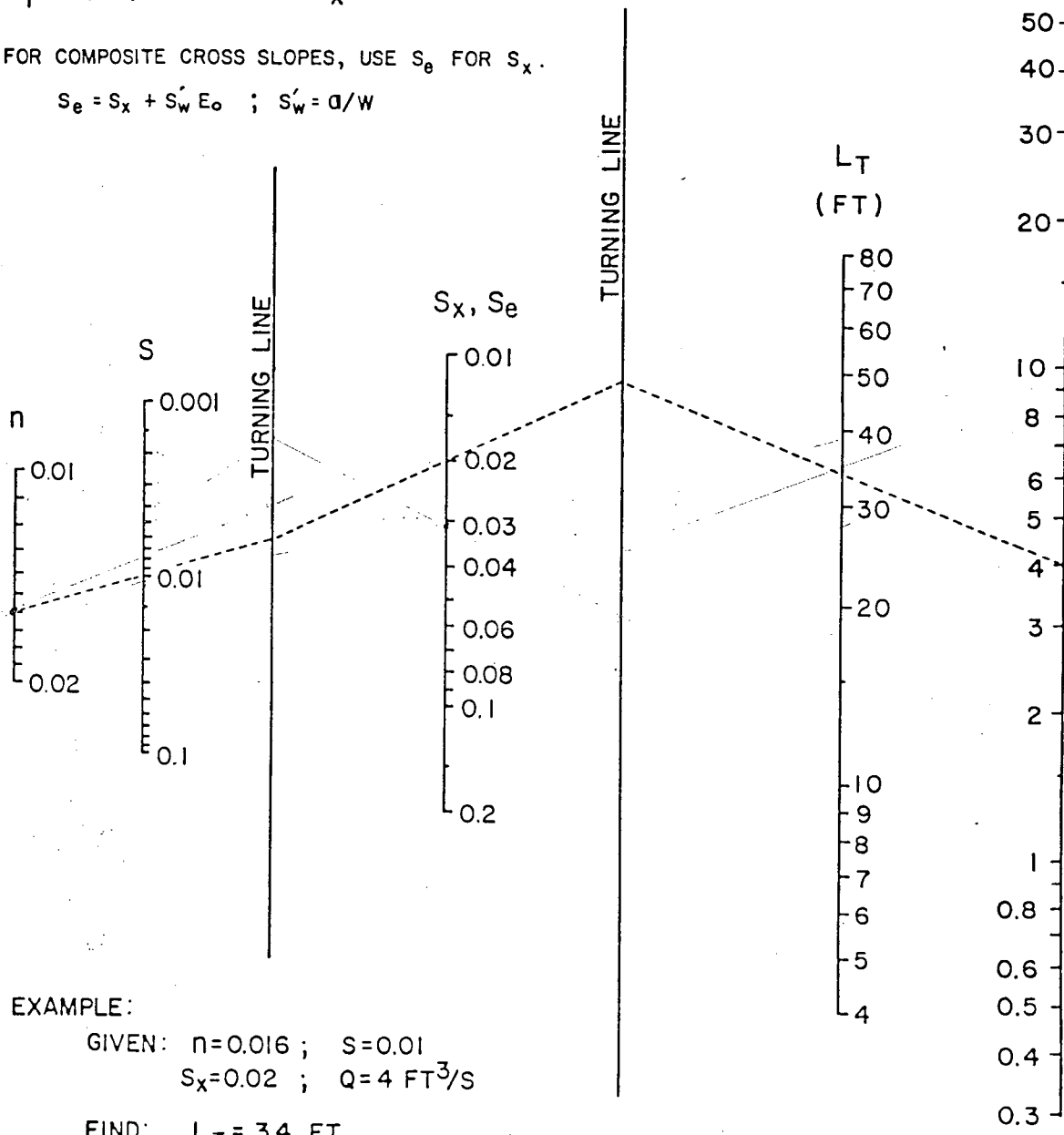
$n = 0.016$



$L_T = 0.6Q^{0.42} S^{0.3} (1/nS_x)^{0.6}$

FOR COMPOSITE CROSS SLOPES, USE S_e FOR S_x .

$S_e = S_x + S'_w E_o ; S'_w = a/w$



EXAMPLE:

GIVEN: $n=0.016 ; S=0.01$
 $S_x=0.02 ; Q=4 \text{ FT}^3/\text{S}$

FIND: $L_T = 34 \text{ FT}$

CHART 9. Curb-opening and slotted drain inlet length for total interception.

From: HEC-12, DRAINAGE OF HIGHWAY PAVEMENTS, Edition 1, Mar. 1984.

100 j, 197,000 100 3 5 4

110 t, northborough third addition

120 t, drainage plan

130 t, storm sewer system no 100 5 year storm

140 i, 104	0.73	2.70	0.00	0.00	3.90	15.00	204.70
150 i, 103	0.72	8.20	0.00	0.00	26.90	15.00	204.70
160 i, 102	0.58	3.40	0.00	0.00	3.60	15.00	204.70

170 m, 101 201.00

180 m, 100 197.00

190 p, 103 102 80.00 24 0.013 65.00 0.00

200 p, 104 102 40.00 18 0.013 135.00 0.00

210 p, 102 101 590.00 36 0.013 55.00 0.00

220 p, 101 100 450.00 36 0.013 0.00 0.00

230 e

Date: 07-21-1986
Time: 15:50:43

Input File: nobo100

northborough third addition
drainage plan
storm sewer system no 100 5 year storm

Storm Frequency = 5-Year

* * * HYDROLOGY * * *

Tributary Area				Hydrology Summation				Conduit Data				
Node to	C	Area (Ac)	Slope (%)	TC(0) (Ft)	I(0) (In/Hr)	Q (CFS)	Sum Q (CFS)	Size	Velocity (Ft/Sec)	Length (Ft)	TT (Min)	TT+IC (Min)
103	102	0.72	8.20	0.0	15.00	5.22	26.90	24"	8.56	80.00	0.16	15.16
104	102	0.73	2.70	0.0	15.00	5.22	3.90	18"	2.21	40.00	0.30	15.30
102	101	0.58	3.40	0.0	15.00	5.22	3.59	36"	4.86	590.00	2.02	17.18
101	100	0.00	0.00	0.0	0.00	0.00	0.00	36"	4.86	450.00	1.54	18.72

Date: 07-21-1986
Time: 15:50:43

Input File: nobo100

northborough third addition

drainage plan

storm sewer system no 100 5 year storm

Storm Frequency = 5-Year

* * * H Y D R A U L I C S * * *

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*****  
Node Hyd-Slope Friction Bend Transition Manhole Deflection Junction Total Hyd-GI Desired Diff.  
(Ft/Ft) (Ft) (Ft) (Ft) (Ft) (Ft) (Ft) (Ft) (Ft) (Ft) (Ft) (Ft)  
*****  
104 0.00138 0.0551 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0551 200.1786 204.7000 4.52  
103 0.01414 1.1311 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 1.1311 201.2546 204.7000 3.45  
102 0.00265 1.5647 0.0000 0.1544 0.0000 0.3852 -0.3074 1.7969 200.1234 204.7000 4.58  
101 0.00265 1.1934 0.0000 0.0000 0.0183 0.1015 0.0133 1.3266 198.3266 201.0000 2.67  
100 0.00000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 197.0000 197.0000 0.00  
*****
```

100 j, 197,000 200 3 7 6

110 t, northborough third addition

120 t, drainage plan

130 t, storm sewer system no. 200 5 year storm

140 i, 206	0.78	2.60	0.00	0.00	0.00	9.20	15.00	203.10
150 i, 205	0.71	8.20	0.00	0.00	0.00	26.50	15.00	203.10
160 m, 204	202.20							

170 i, 203	0.72	5.70	0.00	0.00	0.00	23.80	15.00	201.00
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180 i, 202	0.77	3.60	0.00	0.00	0.00	18.00	15.00	201.00
------------	------	------	------	------	------	-------	-------	--------

190 m, 201 200.00

200 m, 200 197.00

210 p, 206 205	40.00	18 0.013	90.00	0.00				
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220 p, 205 204	380.00	36 0.013	40.00	0.00				
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230 p, 204 202	150.00	36 0.013	80.00	0.00				
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240 p, 203 202	40.00	24 0.013	0.00	0.00				
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250 p, 202 201	350.00	48 0.013	45.00	0.00				
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260 p, 201 200	70.00	48 0.013	0.00	0.00				
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270 e

Date: 07-21-1986
 Time: 15:52:08

Input File: noba200

northborough_third_addition

drainage plan

storm sewer system no 200 5 year storm

Storm Frequency = 5-Year

* * * H Y D R O L O G Y * * *

Tributary Area		Hydrology				Conduit Data											
Node	C Area (Ac)	Slope (%)	Length (Ft)	TC (Min)	I (In/Hr)	Q (CFS)	TC (Min)	I (In/Hr)	Q (CFS)	Sum Q	Size	Velocity (Ft/Sec)	Length (Ft)	TT (Min)	TT+TC (Min)		
206	205	0.78	2.60	0.00	0.0	15.00	5.22	9.20	15.00	5.22	9.20	9.20	18"	5.21	40.00	0.13	15.13
205	204	0.71	8.20	0.00	0.0	15.00	5.22	26.50	15.00	5.22	26.50	35.62	36"	5.04	360.00	1.26	16.26
204	202	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	16.26	5.06	36"	5.04	150.00	0.50	16.75
203	202	0.72	5.70	0.00	0.0	15.00	5.22	23.80	15.00	5.22	23.80	23.80	24"	7.58	40.00	0.09	15.09
202	201	0.77	3.60	0.00	0.0	15.00	5.22	18.00	16.75	5.00	17.24	75.71	49"	6.02	350.00	0.97	17.72
201	200	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	17.72	4.89	49"	6.02	70.00	0.19	17.91

Date: 07-21-1986
Time: 15:52:08

Input File: nobo200

northborough third addition

drainage plan

storm sewer system no 200 5 year storm

Storm Frequency = 5-Year

* * * H Y D R A U L I C S * * *

Node	Hyd-Slope	Friction	Bend	Transition	Manhole	Deflection	Junction	Total	Hyd-GI	Desired	
(Ft/Ft)	(Ft)	(Ft)	(Ft)	(Ft)	(Ft)	(Ft)	(Ft)	(Ft)	Elevation	Elevation	
										Diff.	
206	0.00757	0.3068	0.0000	0.0000	0.0000	0.0000	0.0000	0.3068	201.9352	203.1000	1.16
205	0.00285	1.0839	0.0000	0.0053	0.0000	0.2104	0.9533	2.2529	201.6283	203.1000	1.47
204	0.00285	0.4279	0.0000	0.0000	0.0197	0.0745	0.0143	0.5364	199.3754	202.2000	2.82
203	0.01107	0.4427	0.0000	0.0000	0.0000	0.0000	0.0000	0.4427	199.2818	201.0000	1.72
202	0.00278	0.9723	0.0000	0.0169	0.0000	0.1712	0.3194	1.4798	198.8391	201.0000	2.16
201	0.00278	0.1945	0.0000	0.0000	0.0282	0.1227	0.0139	0.3592	197.3592	200.0000	2.64
200	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	197.0000	197.0000	0.00



Date June 20, 1986 Page 7 of 18

Project Northborough 3rd Addition

Item Drainage Plan

<u>Node</u>	<u>Inlet Condition</u>	<u>Q</u>	<u>L</u>	<u>Q/L</u>	<u>H/h #</u>	<u>H *</u>	<u>Comments</u>
104	On Grade	9.0	10	-			OK
103	Sump	26.9	15	1.8	1.5	0.75	OK
102	On Grade	9.0	10	-			OK
101	MH	-					
100	Outlet	-					
203	Sump	23.8	15	1.6	1.35	0.68	OK
205	Sump	26.5	15	1.8	1.5	0.75	OK
206	Sump	9.2	5	1.8	1.5	0.75	OK
204	MH	-					
202	Sump	18.0	10	1.8	1.5	0.75	OK
201	MH	-					
200	Outlet	-					

see page 8 (h = 6")

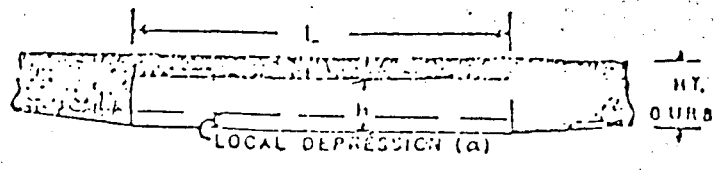
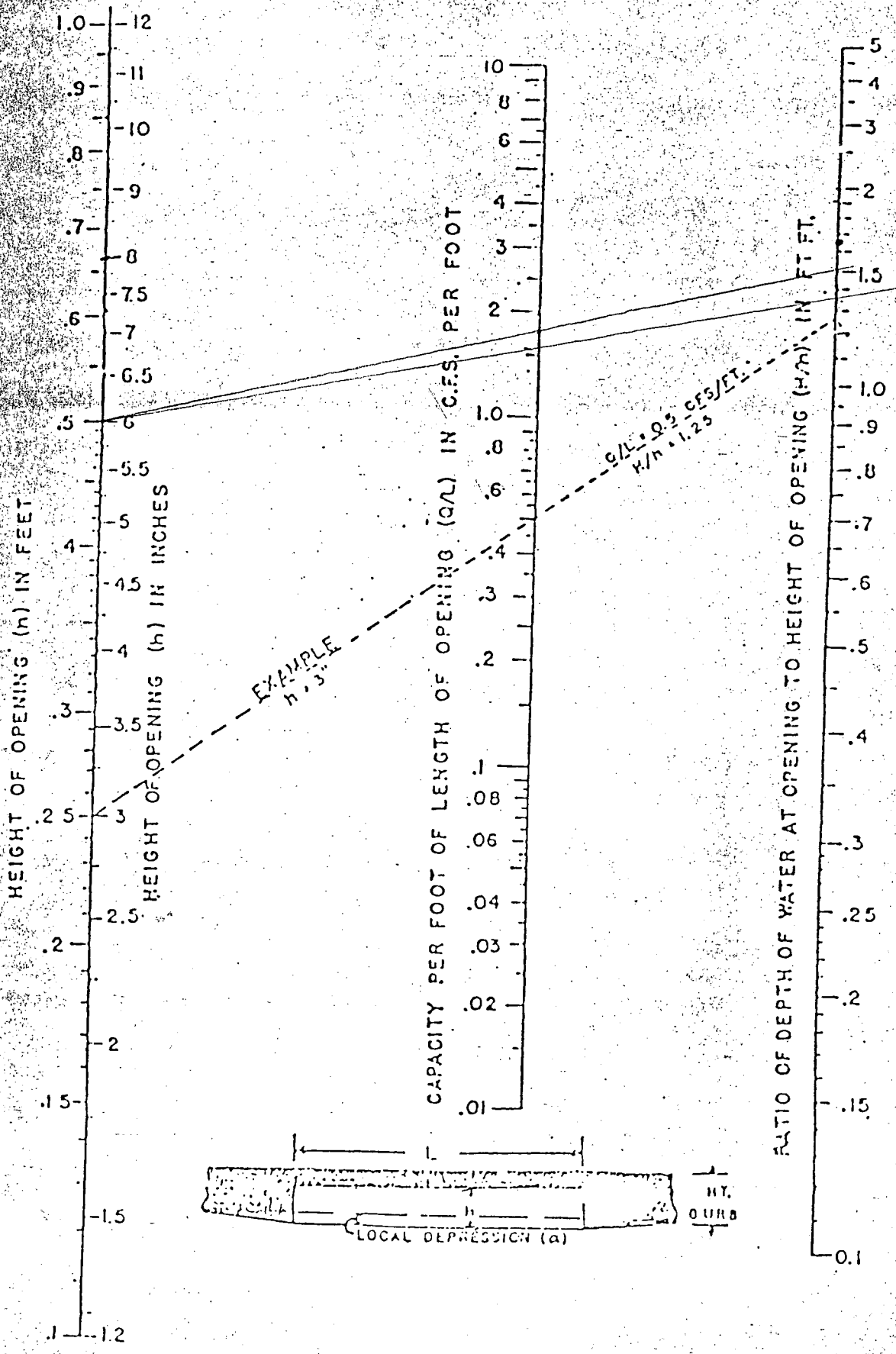
* Allowable H = 10" (This depth results in 4' wide clear lane from street)

SUMP CONDITION ONLY

1073.03

8/12

JULY, 1951





Date June 20, 1986 Page 0 of 18

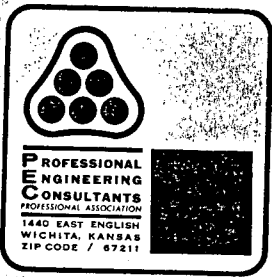
Project Northborough 3rd Addition

Item Drainage Plan

Check street Flow - 5yr.

Node	Qs approach	Flow Distribution	Street Slope	d *	Comment
104	9.0	100% From N	0.78%	0.41	OK
103	26.9	40% From N = 10.8 cfs 60% From S = 16.1 cfs	0.78% 0.50%	0.43 0.55	OK OK
102	9.0	100% From S	0.50%	0.44	OK
101, 100	-	-	-	-	MH & Outlet
203	23.8	50% From SW = 11.9 50% From NE = 11.9	0.59% 0.52%	0.48 0.49	OK OK
205	26.5	90% From N = 23.8 cfs 10% From S = 2.7 cfs	0.96% 0.32%	0.55 0.32	OK OK
206	9.2	90% From N = 8.3 cfs 10% From S = 0.9 cfs	0.96% 0.32%	0.39 0.21	OK OK
204	-	-	-	-	Manhole
202	18.0	60% From SW = 10.8 cfs 40% From NE = 7.2 cfs	0.59% 0.52%	0.46 0.43	OK OK
201, 200	-	-	-	-	Manhole & Outlet

* see nomograph, page 7



Date July 22, 1986 Page 9a of 18

Project Northborough 3rd

Item Drainage Plan

Check 5 yr flow in streets to allow
8' driving lane open

Location	Contrib. Areas	W_1	W_2	W_{total}	W_{allow}	Comment
Stratford (north of Nodes 205 & 206)	205, 206	18.4	12.5	30.9	32	OK
Stratford (north of Nodes 202 & 203)	203, 202	15.7	13.8	29.5	32	OK
Bramblewood (north of Nodes 103 & 104)	103, 104	13.8	13.1	26.9	32	OK
Rock hill (w. of Nodes 203, 202)	203, 202	15.3	14.7	30.0	32	OK

W_1 & W_2 = width of flows on the 2 sides of the street

$W_{allow} = 40' - 8' = 32'$

X-slope = $\frac{1}{8}$ ft = 0.03125 "

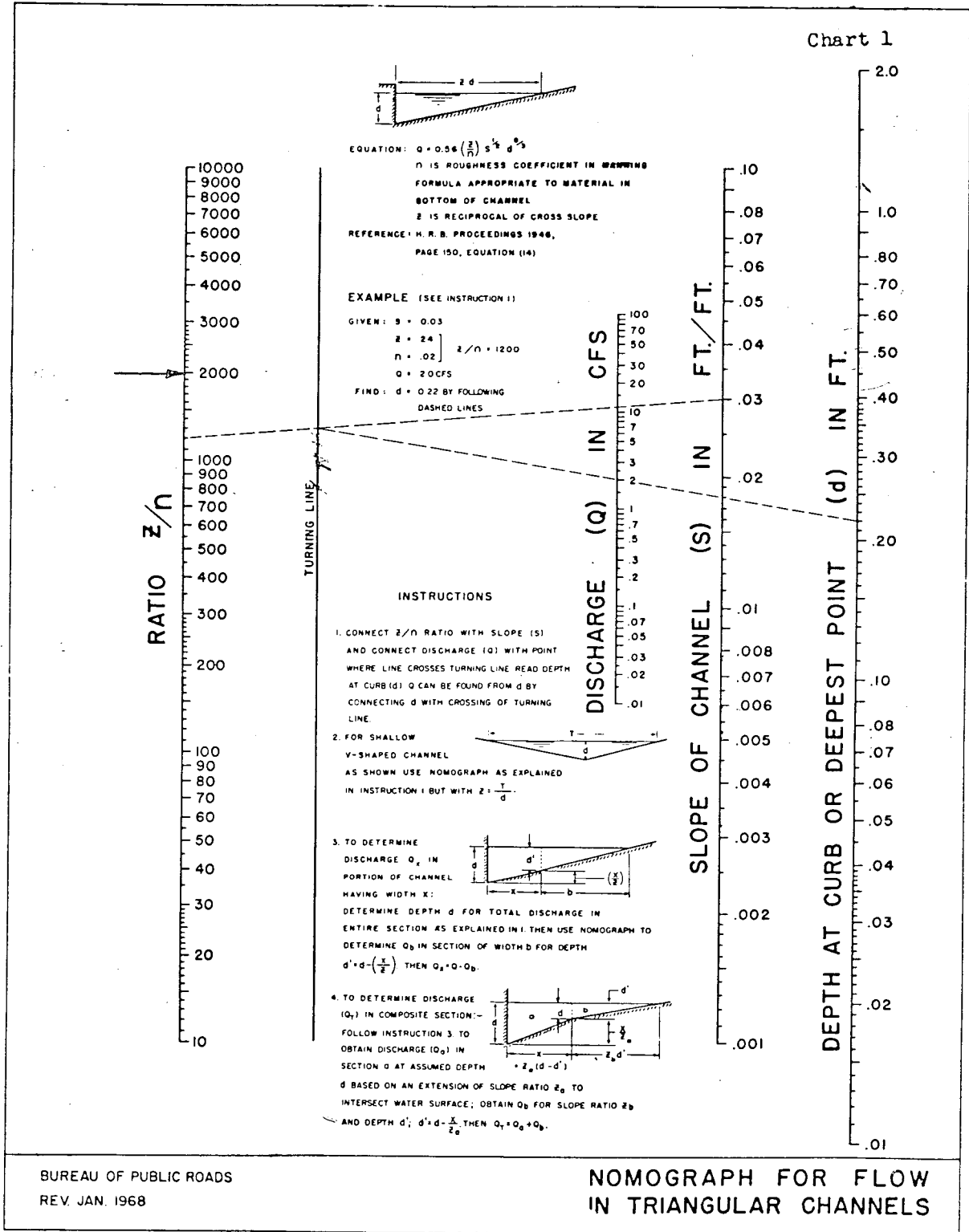
$Z = \frac{1}{0.03125} = 32$

$n = 0.016$

$Z/n = \frac{32}{0.016} = 2000$

Northborough 3rd Addition
Drainage Plan

10/18



100 j, 197.0000 100 3 5 4

110 t,northborough third addition

120 t,drainage plan

130 t,storm sewer system no 100 100 year storm

140 i, 104	0.83	2.70	0.00	0.00	16.50	15.00	204.70
150 i, 103	0.82	8.20	0.00	0.00	49.60	15.00	204.70
160 i, 102	0.71	3.40	0.00	0.00	17.80	15.00	204.70

170 m, 101 201.00

180 m, 100 197.00

190 P, 103 102 80.00 24 0.013 65.00 0.00

200 P, 104 102 40.00 10 0.013 135.00 0.00

210 P, 102 101 590.00 36 0.013 55.00 0.00

220 P, 101 100 450.00 36 0.013 0.00 0.00

230 e

Date: 06-23-1986
Time: 13:12:12

Input File: 100nb100

northborough third addition
drainage plan

storm sewer system no 100 100 year storm

Storm Frequency = 100-Year

* * * H Y D R O L O G Y * * *

Tributary Area		Hydrology Summation				Conduit Data											
Node	C	Area (Ac)	Slope (%)	Length (Ft)	TC (Min)	I (In/Hr)	Q (CFS)	TC (Min)	Q (CFS)	Sum Q (CFS)	Size (In)	Velocity (Ft/Sec)	Length (Ft)	TT (Min)	TT+TC (Min)		
103	102	0.82	8.20	0.00	0.0	15.00	9.97	49.60	15.00	8.97	47.60	49.60	24"	15.79	80.00	0.08	15.03
104	102	0.03	2.70	0.00	0.0	15.00	8.97	16.50	15.00	8.77	16.50	16.50	18"	9.34	40.00	0.07	15.07
102	101	0.71	3.40	0.00	0.0	15.00	8.97	17.80	15.08	8.95	17.76	83.86	36"	11.86	590.00	0.83	15.91
101	100	0.00	0.00	0.00	0.0	0.00	0.00	0.00	15.91	8.77	0.00	83.86	36"	11.86	450.00	0.83	16.55

Date: 06-23-1986
Time: 13:12:12

Input File: 100nb100

northborough third addition
drainage plan
storm sewer system no 100 100 year storm

Storm Frequency = 100-Year

*** HYDRAULICS ***

Node	Hyd-Slope (Ft/Ft)	Friction (Ft)	Bend (Ft)	Transition (Ft)	Manhole (Ft)	Deflection (Ft)	Junction (Ft)	Total (Ft)	Hyd-GI Elevation	Desired Elevation	Diff.
104	0.02467	0.9869	0.0000	0.0000	0.0000	0.0000	0.0000	0.9869	219.9798	204.7000	-14.28
103	0.04807	3.8457	0.0000	0.0000	0.0000	0.0000	0.0000	3.8457	221.8385	204.7000	-17.14
102	0.01581	9.3258	0.0000	0.3371	0.0000	1.3076	2.1140	13.0864	217.9728	204.7000	-13.29
101	0.01581	7.1129	0.0000	0.0000	0.1093	0.0051	0.0792	7.2064	204.5064	201.0000	-3.51
100	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	197.0000	197.0000	0.00

100 J, 197.0000 200 3 7 6

110 t,northborough third addition

120 t,drainage plan

130 t,storm sewer system no 200 100 year storm

140 i, 206 0.88 2.60 0.00 0.00 16.90 15.00 203.10

150 i, 205 0.81 8.20 0.00 0.00 49.00 15.00 203.10

160 m, 204 202.20

170 i, 203 0.82 5.70 0.00 0.00 34.40 15.00 201.00

180 i, 202 0.88 3.60 0.00 0.00 23.30 15.00 201.00

190 m, 201 200.00

200 m, 200 197.00

210 p, 206 205 40.00 18 0.013 90.00 0.00

220 p, 205 204 380.00 36 0.013 40.00 0.00

230 p, 204 202 150.00 36 0.013 80.00 0.00

240 p, 203 202 40.00 24 0.013 0.00 0.00

250 p, 202 201 350.00 48 0.013 45.00 0.00

260 p, 201 200 70.00 48 0.013 0.00 0.00

270 e

Date: 07-22-1986
Time: 10:40:12

Input File: 200nb100

northborough third addition
drainage plan
storm sewer system no 200 100 year storm

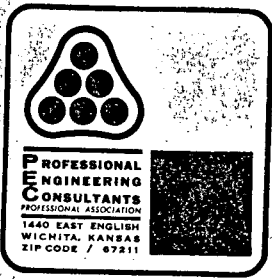
Storm Frequency = 100-Year

*** HYDROLOGY ***

Tributary Area					Conduit Data											

Node	C	Area (Ac)	Slope (%)	Length (Ft)	TC (Min)	I (In/Hr)	Q (CFS)	TC (Min)	Sum Q (CFS)	Size	Velocity (Ft/Sec)	Length (Ft)	TT (Min)	TT+TC (Min)		

206	205	0.88	2.60	0.00	0.0	15.00	8.97	16.90	16.90	18"	9.56	40.00	0.07	15.07		
205	204	0.81	8.20	0.00	0.0	15.00	8.97	49.00	65.82	36"	9.31	380.00	0.68	15.68		
204	202	0.00	0.00	0.00	0.0	0.00	0.00	15.68	8.82	0.00	65.82	36"	9.31	150.00	0.27	15.95
203	202	0.82	5.70	0.00	0.0	15.00	8.97	34.40	34.40	24"	10.95	40.00	0.06	15.06		
202	201	0.88	3.60	0.00	0.0	15.00	8.97	23.30	15.95	48"	9.73	350.00	0.60	16.55		
201	200	0.00	0.00	0.00	0.0	0.00	0.00	0.00	122.21	48"	9.73	70.00	0.12	16.67		

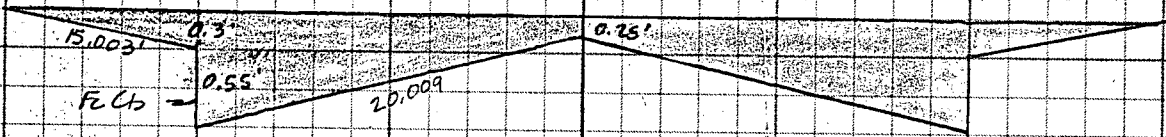


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Project Northborough 3rd Addition

Item Drainage Plan

100-yr. flow in R-O-W
(Parking = T.C + 0.3')



$$n = \frac{(2 \times 15.003 \times 0.03) + (2 \times 0.55 \times 0.016) + (2 \times 20.009 \times 0.016)}{(2 \times 15.003) + (2 \times 0.55) + (2 \times 20.009)} = \frac{1.558}{71.124} = 0.022$$

$$A = 2 \times \left(\frac{1}{2} \times 15 \times 0.3 \right) + (40 \times 0.25) + 2 \times \left(\frac{1}{2} \times 20 \times 0.60 \right) = 26.5 \text{ SF}$$

$$p = (2 \times 15.003) + (2 \times 0.55) + (2 + 20.009) = 71.124$$

$$R = A/p = 26.5/71.124 = 0.3726$$

$$R^{2/3} = 0.517789$$

$$Q_{max} = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

$$Q_{max} = \frac{1.486}{0.022} (26.5)(0.517789) S^{1/2}$$

$$Q_{max} = 926.81 \sqrt{S}$$



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Project Northborough 3rd Addition

Item Drainage Plan

100-yr street flows

Street	Contrib. Areas	Q ₁₀₀	Q _{pipe}	Q _{street}	Street Slope	Q _{allow.}	Comment
Bramblewood (n. of Rockhill)	40% Node 103 + Node 104	36.3	0	36.3	0.78%	81.8	OK
Bramblewood (s. of Rockhill)	60% Node 103 + Node 106	47.6	0	47.6	1.15%	99.4	OK
Rockhill (w. of sump)	104, 103, 102 40% 203 50% 202	109.3	34.4	74.9	0.59%	71.2	OK*
Stratford (n. of sump)	206, 205	65.9	0	65.9	0.96%	90.8	OK
Stratford (s. of crest)	206, 205	65.9	35.6	30.3	0.52%	66.8	OK
Rockhill (e. of sump)	206, 205 60% 203 50% 202	98.2	35.6	62.6	0.52%	66.8	OK*

* USE SW GRADE = T.C + 0.4' ON ROCKHILL STREET



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Project Northborough 3rd Addition
Item Drainage Plan

CHANNEL / DETENTION POND IMPROVEMENTS

See Drainage Plan For Northborough 2nd Addition dated 5-2-83 for channel & detention pond calculations.

The storm sewer layout for Northborough 3rd Addition is slightly different due to the new street layout.

However, the differences in Q_{100} into the pond due to the new layout is minor. Therefore, the pond data as noted in the Northborough 2nd Drainage plan is still valid:

$$DWS_{100} = 198.9$$

$$\text{Static Pool} = 194.0$$

$$\text{Pond Bottom} = 189.0$$

$$\text{Outlet Pipes} = 2-36" \text{ RCP} \quad \begin{array}{l} E @ \text{ Pond} = 194.0 \\ E \text{ out} = 193.5 \end{array}$$